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SOME NEURAL AND GLANDULAR BASES OF LEARNING

Thomas H. Eames

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Very little is known of the mechanism of the thought processes involved in learning or the nature of the changes in the brain which make retention and memory possible, but a good deal of interesting and useful knowledge about the neural and glandular processes and influences is being collected through research. A portion of this knowledge is summarized here. It contributes to the teacher's practical understanding of her pupils and a greater appreciation of their learning problems. It tells her a small part of what is going on inside of them while learning. It also throws light on problems of school failure and carries implications for motivation, teaching approaches to different kinds of pupils, and other classroom problems.

Dr. Eames has been conducting research on the physical factors involved in learning since 1930, both as an independent physician and in connection with work, first at the Harvard Growth Study and Psycho-Educational Clinic and later at the Boston University School of Education where he joined the full-time faculty in 1954. Over one hundred of his research reports have appeared in European and American educational, psychological, and medical journals.

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Some Neural and Glandular Bases of Learning

THOMAS H. EAMES

Chapter

1. Some Neurological Bases of Learning 3

2. Some Glandular Bases of Learning 23

3. Recent Studies with Learning Implications 33

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[1]Leton,
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[2]Eames,
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[3]Cobb,
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CHAPTER 1

Some Neurological Bases of Learning

A thorough knowledge of the psychology of learning is essential for any teacher, but a further appreciation of what is known of the physiology of learning contributes to her effectiveness, explains some hitherto obscure problems, and opens up new vistas.

Educational problem cases are often interpreted in terms of their superficial features toward which teaching is directed, rather than to the deeply underlying causes of failure. Donald A. Leton, of the University of California, has recently pointed out that teachers often explain the adjustment difficulties of the brain-injured child in terms of reading disability or speech difficulties.[1] This is no less true of other physio-pathological conditions that interfere with learning. A great deal of pedagogic effort is unintentionally thrown away in an attempt to teach pupils whose undiscovered handicaps, often of a mild nature in themselves, prevent the child from learning or interfere with the learning process.

There is a dearth of literature on teaching techniques and approaches to pupils with such handicaps. Since 1934 the author has given courses in the field at Boston University School of Education, under the titles of "Physical Handicaps to Learning" or "Physical Factors in Reading." Much of his research on visual factors in reading was summarized in the February 1959 issue of this magazine.[2] A little over a hundred of his studies, covering sensory, neurological, glandular, general physical, and other conditions have appeared in other professional journals in the fields of education, psychology, and medicine.

Nearly twenty years ago Dr. Stanley Cobb, Bullard Professor of Neuropathology at Harvard Medical School and Psychiatrist in Chief at the Massachusetts General Hospital, pointed out that it is impossible for a human function to take place without an organ to perform it.[3] This had long needed to be said authoritatively. Common sense and an appreciation of physics and chemistry would lead any serious student to the same conclusion. With this in mind, we look for the organ of learning and find it to be the brain, which is the central station of the nervous system.

The cortex or bark of the brain, commonly called the gray matter, is the part involved in learning and it contains innumerable nerve cells, or neurons, which are the building blocks of the nervous system. Each neuron consists of a nerve cell with short branch-like structures at one side, termed dendrites, and a long filament (axon) on the other side which terminates in a brush-like ending. Nerves transmit impulses that behave much like those of electricity. They enter over the dendrites and pass out along the axon. When they pass on to other neurons the impulses cross from the axon of one to the dendrites of another, the junction point being called a synapse. This structure contains an electrolyte composed of acetylcholine and thiamine, and it is over this that the impulses travel rather than

[1]Leton, D. A., "A New Frontier in Special Education." *Education*, 80: 349–353. February 1960.

[2]Eames, T. H., "Visual Handicaps to Reading," *Journal of Education*, 141: 1–35, February 1959.

[3]Cobb, S., *Borderlands of Psychiatry*, pp. 21 and 46. Harvard University Press, Cambridge, 1943.

directly by actual contact. Although it is almost impossible to tire a neuron to a measurable degree by using it alone, fatigue appears with the use of a neural circuit involving a synapse. If such a linkage is involved in a neural pathway over which learning is taking place, that learning can be slowed down or impeded by anything that interferes with synaptic conductivity, such as a change in the concentration of the electrolyte. Recently Donald Smith has used these facts in the development of a synaptic theory of severe reading disability.[4]

If the brain is to learn, the material must reach it from the environment and it does so over the sensory channels of sight, hearing, taste, touch, and smell. All of these functions take place in the brain but peripheral receptor organs such as the eyes, ears, nose, and fingers mediate between it and the environment. These are supplied with specialized receptor cells. The eye has its rods and cones, the ear its cochlea receptors, the nose its olfactory receptor filaments, the tongue its taste buds, and the skin its touch corpuscles, all being connected with the brain by pathways composed of neurons and synapses. The receptors are acted upon in various ways and transmit information to the brain where it is perceived. Obviously, perception has its individual differences, since all that anyone knows of the world outside himself comes to him as sensory perceptions. The philosophically minded have argued that perceptions are the only realities.

Electroencephalography, a method of recording the electrical activity of the brain, has thrown some light on learning problems but has not been used very much in this way. Burks[5] studied the behavior characteristics of 137 school problem children and compared them with a control group of 94. Those with abnormal EEG tracings displayed *greater difficulties in the perceptual-academic functions* and when such tests as the Wechsler Intelligence Scale for Children were used, they had *more trouble in the verbal sub-tests.*

Lindsley[6] found that people with speech difficulties exhibit abnormalities in alpha rhythm, especially when blocking, while Streifler and Gumpertz[7] reported a high percentage of abnormal EEG curves among people with speech disorders and concluded that they indicate disturbances in the regulation of the bioelectrical brain potentials in stutterers. Recent experiments, still inconclusive and not completed, suggest *a difference between the EEGs of reading failures and non-failures.* Cornil and Gestaut studied lateral dominance electroencephalographically. Their report will be discussed in a later paragraph.

Attention is always important in learning. It appears to be a state of sensitized consciousness in which an incoming impulse initiates a kind of resonance pattern and perpetuates it through some form of circular or recurrent reflex. Cobb calls this reverberation. One neurological explanation, based on what is known of the brain, is that the hypothalamus sensitizes the thalamus and makes it ready to receive incoming impulses and that when they arrive they set up recurrent reflexes or reverberations over a nerve circuit including the cortex and the thalamus, sustaining them

[4]Smith, D. E. P., "A Synaptic Transmission Theory of Severe Reading Disability," *University of Michigan School of Education Bulletin*, 29: 25–28. November 1957.
[5]Burks, H. F., "Brain Pathology," *Exceptional Children*, pp. 169–174, December 1957.
[6]Lindsley, D. B., "Bilateral Differences in Brain Potentials from Two Cerebral Hemispheres in Relation to Laterality and Stuttering," *Journal of Experimental Psychology*, 26: 211–235, 1940.
[7]Streifler, M., and F. Gumpertz, "Cerebral Potentials in Stuttering and Cluttering," *Confinia Neurologica*, 15: 344–359, 1955.

as long as necessary. The length of time that this can continue would determine the span of attention. Attention is a selective process. What determines its selectivity is still obscure but it is known that maturation plays an important part in the kind of situation that will get attention and the length of time it can be held. Young children attend to externals and are preoccupied largely with sense perceptions. They flit from one situation to another, the maximum span of attention increasing with age in childhood. Secondary school pupils can attend for longer periods and respond not only to sensory perceptions but also to social needs. Some of the schoolroom devices to gain and hold attention include the following: *Use of intense stimuli, novelty, repetition, and motivation.* Attention is also influenced by the pupil's own intent to learn.

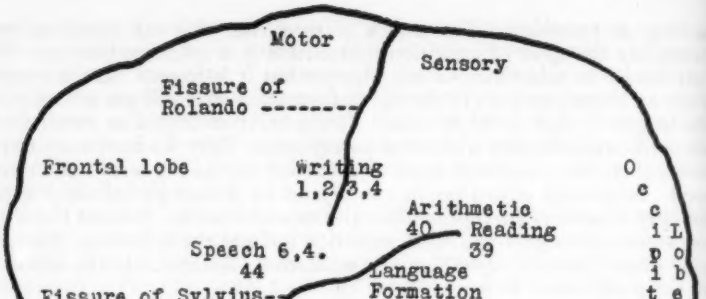
When a person learns, some change takes place in the physiochemical conditions of the brain cells. Orton called these changes "engrams" but their nature has not been established, nor do we know exactly where they are laid down in the tissues. These changed conditions make retention and memory possible. The parts of the brain are very intimately connected with each other in what might be considered as complicated nerve networks and the general explanation of memory is that it occurs when resonance patterns occur in them. Probably extensive parts of the brain are influenced to a greater or lesser degree in learning and when later incoming perceptions activate certain resonance patterns conscious memory results.

Although memory is probably a very general matter in the broader sense there are certain areas known to be associated with specific types of memory such as visual, auditory, and symbolic types, especially as related to language symbolization. These are usually in or associated closely with corresponding centers which control the respective functions of which these visual, language, and other memory areas are parts. They are more or less grossly defined and if removed surgically or damaged by accident or disease the individual loses the function with which they are associated to the extent of their loss or damage. The lost or impaired functions may be relearned over a period of time through education of adjacent and similar tissue which remains undamaged, or by development and training of the corresponding area in the opposite hemisphere of the brain. There are wide individual differences in the ability to make this adaptation to injury. Some never regain their lost function while many do to different extents. Neurosurgery and subsequent attempts at rehabilitation in accident and military cases have contributed a great deal to the present understanding of the areas involved.

The brain is made in two identical hemispheres connected by a bridge called the corpus callosum. The average right-dominant person develops his language function on the left side only, although the other appears grossly and histologically exactly similar. With this in mind we turn to a discussion of some of the cortical areas involved in learning, making use of the Brodmann classification in referring to them.[8]

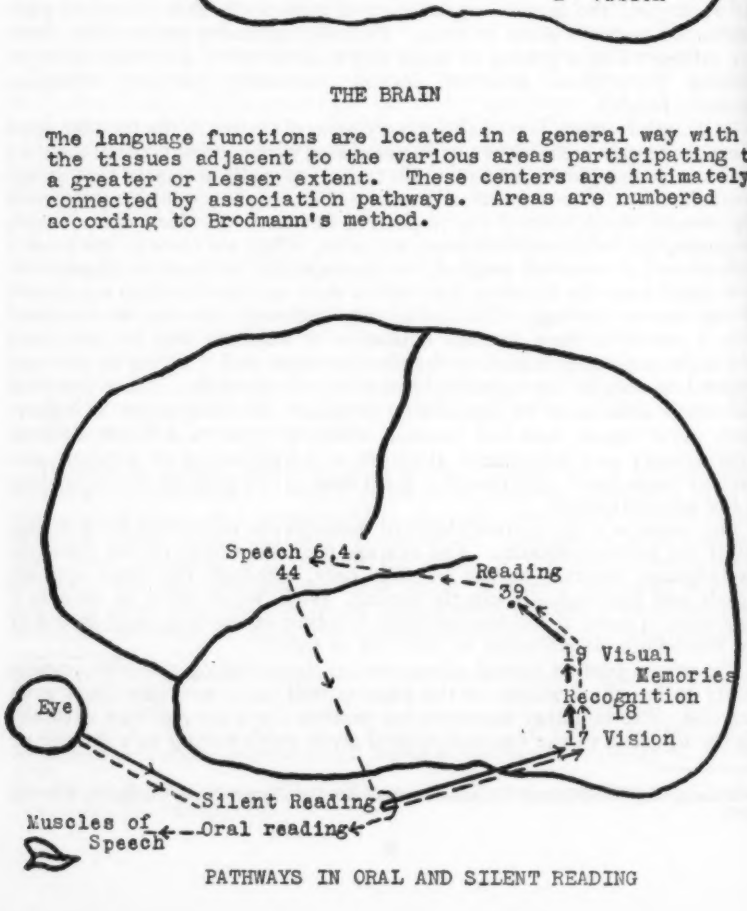
The major part of formal education involves reading and this implies ability to see the symbols on the page as well as to associate them with meaning. The language functions are localized in a general way with the tissues adjacent to the various cortical areas participating to a greater or

[8]Brodmann, K., *Vergleichende Lokalisationslenre der Grosshirnrinde.* J. A. Barth, Leipsig, 1909.



THE BRAIN

The language functions are located in a general way with the tissues adjacent to the various areas participating to a greater or lesser extent. These centers are intimately connected by association pathways. Areas are numbered according to Brodmann's method.



PATHWAYS IN ORAL AND SILENT READING

lesser extent. These centers are intimately connected by association fibres which permit them to influence one another.

At the posterior pole of the occipital lobe (back of the brain) one finds Brodmann area 17 (area striata) which is the center for vision without recognition or understanding. The macula area is represented anteriorly on either side of the calcarine fissure. This area permits one to see objects but not to understand or recognize them. If the area is irritated flashes of light are seen, while destruction results in blindness if both halves of the brain are affected. If the area is destroyed in one hemisphere and not in the other homonymous hemianopsia (half vision) results. Area 18 (para-striate area) surrounds area 17 and here visual recognition by size, shape, or color is experienced. Irritation of this area results in visual hallucinations of light, color, or stationary objects. When area 18 is damaged or undeveloped, and area 17 is intact, one is able to see but not to recognize (or to recognize imperfectly) what he sees.

Area 18, in turn, is surrounded by area 19 (peri-striate area) which involves a more complex aspect of recognition. *This is the seat of visual memory* (revisualization) and enables one to recall objects previously seen and probably to compare the object being observed with similar objects seen before. The activity of the center depends on nerve impulses reaching it via areas 17 and 18 as well as via association pathways from the centers associated with perception of odors, tastes, sounds, touch, etc. Irritation of area 19 gives rise to active hallucinations in which the person sees objects such as people moving about and sometimes doing curious things. Lesions in area 19 result in impairment of visual attention as well as visual confusion and inability to get around, even in familiar surroundings. When areas 17 and 18 are intact one can see (area 17) and recognize objects (area 18) but cannot remember their size, shape, or color.

Near area 19 is area 39 (centering in the angular gyrus). This is the *reading area* and it *combines* the functions of recognition and revisualization of letter and word symbols, syllables and abbreviations. Area 39 is closely connected through association pathways with the visual areas (17, 18, and 19) as well as with the hearing areas, 41 and 42 (known collectively as Wernicke's area), with the speech area, 44 (Broca's area), with area 40 (supramarginal gyrus) which controls recognition and revisualization of number symbols, with the language formation area which lies adjacent to areas 39, 41, and 42, and takes in parts of areas 22 and 37, and with many other parts of the brain including the centers for writing and eye movement.

Lack of development, injury, or disease in area 39 interferes with the *ability to learn to read or*, in the case of disease or injury which is acquired after reading has been learned, *impairment of reading ability*. If the area is very extensively damaged or underdeveloped, the pupil is able to see the print with areas 17, 18, and 19 and can recognize it as *word forms* but cannot read it. Probably a very large number of the children who have trouble in learning to read have some deficiency in this area. Intensive remedial teaching usually results in the development of some reading ability, possibly by modifications in marginal tissue, by changes in the tissues of the area itself if they are at all able to function, or by development of a secondary language center on the opposite side of the brain. Immediately in front of area 39 is the mathematical area, 40 (supramarginal gyrus). This, like area 39, is concerned with recognition and revisualization of symbols but appears to be more closely related to mathematic symbols than those of letters and words.

It is probable that areas 39 and 40 are so similar in function that the latter *may provide suitable cells for modification in remedial reading* instruction when there are defects or deficiencies in area 39 and vice versa. The reader is *not* to infer that these neurological conditions are the only causes of reading or arithmetic failure.

The areas discussed thus far exhibit varying degrees of dominance. In the average right-handed, right-eyed person areas 17, 18, 19, 39, and 40 on the left side of the brain are usually the dominant ones. Area 18 exhibits some dominance tendency, area 19 a good deal more, while dominance is a very marked characteristic for areas 39 and 40, so much so, in fact, that when injured here, some cases never develop the corresponding area to a point where useful symbolization is possible.

When reading, the eyes do not flow along the lines of print but make alternate pauses and forward movements. Reading takes place during the pauses but not during the advances. The cerebral mechanism that controls such movements is somewhat complex. The motor nerves of the eyes originate in cell bodies located in the brain stem, the mid-brain, and the lower pons, conjugate movements of the two eyes probably being controlled through the abducent nucleus in the latter location. However, *voluntary* eye movements are determined by the motor eye cortex, located in the posterior third of the middle frontal convolution,[9] or back part of areas 8 and 9. This indicates how involved the apparently simple process of moving the eyes along a line of text really is. Any defect in these centers or their connections with others involved in reading may interfere with easy, efficient performance of the act. Fortunately a certain amount of compensation is possible and persons with not too severe defects of the ocular muscles and their neural connections may be able to read in spite of them, since reading is a cerebral process. Serious defects of the eye muscles or the nerves and centers which manage them are likely to interfere with reading and may require professional attention.

There are various parts of the brain through which bundles of association fibres course. Anything that impairs their function is likely to be attended by difficulties referred to the centers which they connect. For example, *loss of auditory memory* may result from impaired function of the fronto-occipital fasciculus and the *ability to associate auditory and visual memories* correctly is interfered with by difficulties in the dorsal superior longitudinal bundle of the superior frontal fasciculus. *Disturbed eye movements in following lines* sometimes result from lesions in the posterior longitudinal bundle of the median longitudinal fasciculus, the fibres of the superior cerebellar peduncle or the aberrant pyramidal fibres. *Reduced eye span* may be caused by difficulty in the optic radiations.

Nielsen[10] and Cobb[11] attach a good deal of significance to that part of the temporal lobe of the brain that lies between the hearing and the reading areas; the upper part of area 37 and the back part of area 22. *Association of sounds with visual symbols* appears to occur as a result of connections between the auditory and reading areas which pass through this section of the brain. When one considers that the teacher presents the visual word symbol simultaneously with pronunciation of the word (which itself is a sound symbol for the thing or idea) in order to establish association of the

[9]Lyle, D. J., *Neuro-ophthalmology*, pp. 49–51. Charles C. Thomas, Springfield, Ill., 1945.
[10]Nielsen, J. M., *Agnosia, Apraxia, Aphasia*, p. 210. Los Angeles Neurological Society, Los Angeles, 1936.
[11]*Op.Cit.*, p. 43.

visual and auditory equivalents in the mind of the learner, the importance of this area is easily appreciated. It has been called the language formation area. Cobb states that when it is removed at operation the ability to name nouns is lost. Although the patient knows what the object is and can tell its use he can no longer name it.

Word blindness (*alexia*) is generally believed to result when there is injury or failure of development in the angular (area 39) and supramarginal (area 40) gyri of the brain. The commonest causes of the condition appear to be failure of full development, vascular lesions, tumors, and inflammations. Probably most of the cases seen by teachers are due to the first of these. If the part affected is on the dominant side of the brain a group of symptoms known as "Gerstman's syndrome" may occur. This symptom complex includes inability to read (alexia), inability to recognize objects by touch (astereognosis), inability to write (agraphia), confusion of orientation, homonymous hemianopsia, and inability to do arithmetic. The complete Gerstman's syndrome is likely to appear in its entirety only in very severe cases, others exhibiting modifications of it in various degrees. However, it may serve teachers and psychologists as a suggestion of possible organic disorder and children displaying it should be referred to a neurologist. Lyle[12] states that Gerstman's syndrome is produced when both the angular and supramarginal gyri on the dominant side are implicated. He also cites a case in which the patient missed the left-hand letters of words. Reading or turning the eyes to the left in reading produced nervousness and fatigue. Examination revealed congenital absence of the corpus callosum, a brain structure containing transverse fibres which connect the two hemispheres.

Specific Reading Disability. When a child fails to learn to read and no injuries, diseases, or physical or mental abnormalities are detected, physicians often classify him as having "Specific Reading Disability" which several have claimed to be a separate entity.[13, 14, 15] Recently a kind of symptom complex for the condition has emerged in medical circles and it is said to be associated with ambidexterity, speech defects, and a tendency to occur in other members of the same family. Psychiatrists seem to favor individual rather than group teaching in such cases, emphasizing phonetic and kinesthetic methods.

Naturally, all concerned with language disabilities advise a thorough search for possible physical handicaps which may contribute to the production of the condition, but opinion as to teaching differs. The author believes that the instruction should be fitted to the individual pupil and his capabilities, no matter whether we consider the case one of "Specific Reading Disability," "Word-blindness," or just plain reading failure due to psychologic and pedagogic factors. Well-trained remedial teachers have *many* effective techniques at their command and should use any or all as necessary to produce a *good, practical result* in the particular case.

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[12]Lyle, D. J., *Op. Cit.*, p. 270.

[13]Eustis, R. S., "Specific Reading Disability," *New England Journal of Medicine*, 237: 243–249, August 21, 1947.

[14]Park, G. E., "Reading Difficulty (Dyslexia) From the Ophthalmic Point of View," *American Journal of Ophthalmology*, 31: 28–34, January 1948.

[15]Gallagher, J. R., "Specific Reading Disability," pp. 436–440, *New England Journal of Medicine*, March 23, 1950.

Individual teaching may be more beneficial in the very early stages of remedial work but early return to group instruction, even on a remedial teaching basis, helps to keep the child from thinking too much of himself as a special problem and encourages him to cooperative effort. The child who is dragged about from teacher to psychologist to optometrist to family physician to ophthalmologist to neurologist to psychiatrist; from clinic to clinic and from office to office, often becomes hypochondriacal and his learning is impeded further. Naturally, such a pupil should be seen by any specialists who may be able to help him but in the last analysis the problem boils down to a pedagogic one and all concerned should avoid doing anything that may impair motivation and the will to participate in the learning act.

The room teacher should apply all her teaching techniques and pedagogic ingenuity before deciding that the child cannot be taught in the classroom or with special help, either from her or from the special reading teacher, if the school has one. Similarly, doctors should not be hasty in assigning the diagnoses of "Word Blindness" and "Specific Reading Disability" but should bear in mind the possibility of failure due to absences, frequent changes from school to school, emotional and pedagogic causes.

Oral and Silent Reading. Teachers generally recognize that silent reading is easier for the child than oral reading, while an oral reading method is easier for the teacher to use. For this reason non-oral methods of teaching reading have been evolved. They are based on the idea that vocalization has a retarding influence, while silent reading involves direct association of printed symbols and meaning.[16] Silent reading is emphasized and oral reading is held to a minimum. Proponents of such methods may find a good deal of corroborative material in the neuro-physiology of reading.

Silent reading is a less complex act, requires a shorter neural path, and probably offers less possibility for inappropriate adventitious reflexes and confusions arising from them. Silent reading involves brain areas 17, 18, 19, and 39. Oral reading involves the same areas and *in addition* area 44 (speech) with parts of areas 4 and 6 (motor components of speech) and finally the nerve paths from these areas back to the muscles of speech. Therefore it is seen that while silent reading involves only an efferent path to bring the impulses to the brain from the environment, the oral method requires both an efferent and an afferent path as well as the involvement of additional cerebral areas.

It is recognized, of course, that brain areas used in both oral and silent reading have connections through association pathways with both known and as yet unlocalized psychic areas. However, the more brain areas directly involved in an act the more association paths, like side tracks, there are available through which the impulses may be interfered with or lost. Research has shown that persons reading silently make shorter and fewer fixations and also fewer regressions than in oral reading. The evidence therefore supports and to some extent explains why silent reading is easier for the pupil.

Basing his opinion on classroom and clinical observations as well as the facts briefly outlined in this section the author feels that silent reading should be emphasized more than it has been, although he recognizes that economy may dictate rather considerable use of oral reading in the intro-

[16]Buswell, G. T., "Perceptual Research and Methods of Learning," *Scientific Monthly*, LXIV: 521–526, June 1947.

ductory months when the teacher must follow the pupil's reading progress very carefully.

The Pupil with Brain Damage. During the last several years there has been an increased interest in slow learning attributed to brain damage. Such defectiveness can result from developmental inadequacy, birth injuries, and accidental trauma. These injuries occur in all degrees of severity from the sub-clinical to the severe, but most writers concern themselves with the child whose damage is serious enough to be reflected in marked physical and learning incapacities. It must not be forgotten that milder damage accounts for many of the cases of apparent normalcy which fail to respond to the usual teaching techniques.

When such conditions are suspected a very careful general physical and neurological study may reveal the source of the interference with learning. Generally speaking, if there is very serious brain damage the teacher observes an incoordinate, erratic, uninhibited, hyperactive, and often socially unacceptable child. His emotions are shallow and transient, his mind wanders from his assigned work, he indulges in flights of fancy, and is often distracted by non-essentials. He is likely to appear busy when he isn't and his work is seldom completed. He fails to follow the thread of what he reads and becomes preoccupied with pictures and page numbers. He doesn't perceive relationships in number systems and often uses words he does not understand.

The commonest causes of brain damage of significant amount among the author's cases have been concussion, meningitis, and encephalitis. The first is an injury, the second and third diseases. Taken collectively the brain damage cases seen by the author have exhibited more hypermetropia of 1 diopter or more (far-sightedness), more amblyopia (dim vision), more eye coordination difficulties of a significant amount at book and desk distances, more strabismus (constant eye deviations), and more emotional disturbance than similar groups of school children of comparable age without brain damage. There also appeared a different clinical picture when the damage was due to injury, than when due to disease. Those with a history of brain injury by external force exhibited more frequent semantic aphasia and amblyopia, while those whose damage resulted from illness more commonly displayed retarded speed of visual perception and defects of eye muscle control.[17]

Many brain-damaged children are so defective that it is unfair to the rest of the pupils to keep them in regular classes. They often inflict injury on other children and sometimes on the teacher, they distract the class and interfere with its progress. The outlook for them is poor, few ever making a sufficient recovery to take part in regular school activities. The brain-damaged child who is so badly handicapped must be institutionalized. He will make better progress in a hospital-school than in regular classes.

The classroom teacher can do certain things to help the child who is somewhat adaptable and can fit into the class to a reasonable degree. She can use motor activity in connection with assigned tasks since it helps to hold attention. Tracing, writing, and drawing are helpful adjuncts to most learning problems. A great deal of drill will be necessary since forgetting is rapid. The drill should be kept close to the child's experience so he will have a feeling of familiarity with some element of the situation. Such

[17]Eames, T. H., "Reading Failures and Non-failures in Children with Brain Damage," *American Journal of Ophthalmology*, 47: 74–77 (Part I), January 1959.

people tend to lapse into despair when meeting a situation in which they feel inadequate. Assignments and practice periods must be short. Matching words or numbers with cards or pegs is helpful and a marker under the line helps to keep the child from wandering off into other parts of text or example. Visual-motor skills should receive special emphasis. Notwithstanding these general techniques the teacher must resign herself to pupil progress that is out of all proportion to the effort expended. Any advance in achievement should be cause for her to congratulate herself.

Laterality or Cerebral Dominance. Cerebral dominance or lateral dominance are terms relating to which side of the body is functionally more efficient or preferred for most activities. This is most familiar as *handedness* and *eyedness*, although it may be found to apply to any of the paired organs. Most people are right handed and right eyed. They are said to have dextrality or right dominance. Variations from this condition have been blamed for many language disorders and disabilities, especially in the fields of speech, writing, spelling, and reading.

There are two identical halves of the brain, each termed a cerebral hemisphere, one on the right, the other on the left. No anatomical difference between them has ever been found. However, one or the other tends to dominate and manage the functions of the body. Right dominance or dextrality results when the *left* hemisphere is the leader and left dominance or sinistrality when the *right* hemisphere leads. In other words the dominant side of the body is *opposite* to the side of the dominant cerebral hemisphere. The generally accepted theory, in recent years, is that both hemispheres are potentially equal at birth but, on the one hand, congenital factors may predispose to the establishment of dominance in one hemisphere, while the environment, which is adapted to dextrality, encourages development of right dominance. If the inherited tendency is strong enough and happens to favor left dominance the effect of the environment may not be sufficient to change it. If both the inherited and environmental influences are dextral the individual becomes right dominant. Probably a weak congenital left dominance might be changed by the stronger influence of the environment. Some people have *uncertain dominance*, both cerebral hemispheres being about equal in dominance tendencies. In such a case either might take the lead at any time, giving rise to uncertainty and indecisiveness on the part of the pupil. Others may present a condition known as *crossed dominance* in which one hemisphere leads in some activities while the other dominates in different ones. This may be illustrated by the fairly common condition of left eyedness with right handedness. The frequencies of occurrence of the various forms of dominance among the author's cases have been as follows:

	Reading failures	*Unselected*
Eyedness		
Right eyed	58%	61%
Left eyed	36	38
Amphiocular	6	1
Handedness		
Right handed	79	88
Left handed	18	12
Ambidextrous	3	0
Crossed dominance		
Left eyed-right handed	38	28
Other types	19	12

Right dominance being the most common is usually regarded as "normal" and departures from it are deemed unfavorable. The left-dominant individual may have some trouble in fitting into the right-handed environment. Common difficulties of this nature include the awkward writing position of left-handed people when trying to produce script from left to right and also the tendency to reverse such words as "saw" and "was," sometimes attributed to left dominance as well as to poor visual discrimination. Most people can be shown to have some slight dominance tendency but when none is in evidence one is said to have *uncertain dominance.* In this case one side of the body appears to be about as functional as the other and neither takes the lead, or either may take it. This is blamed for *confusion, indecision, and errors in reading, spelling, writing, and speech.* While lack of dominance may operate as a language handicap there are times when equal functional ability of both sides of the body is advantageous.

Anatomical studies have never demonstrated any difference between the two cerebral hemispheres, regardless of which was dominant and so it has been assumed that dominance is a functional preference, determined, as previously explained, by hereditary and environmental influences. Cobb[18] objects to the term "functional" and attributes dominance to some ultramicroscopic arrangement of the cortical material, probably of a chemical nature. Cornil and Gastaut[19] studied dominance in 120 adults and 30 children by means of electroencephalography. They found the alpha rhythm more regular, more rhythmic, and of greater amplitude on the dominant hemisphere. Lindsley[20] compared groups of persons with and without speech defects by electroencephalography and found that the speech cases exhibited abnormalities in alpha rhythm which were more marked during blocking. The late Samuel T. Orton[21] elaborated a very ingenious theory of dominance involving bilateral irridation of both cerebral hemispheres with the laying down of "engrams" or memory traces in each; those in one hemisphere being the mirror images of those in the other. When those in the right hemisphere (left dominance) were active they gave rise to tendencies toward mirror writing and reversals. This complex, carefully worked out theory has not been proven but serves as a useful hypothesis. Dr. Walter F. Dearborn [22] made very important contributions to the understanding of reading failure in terms of confused motor activity, resulting from dominance variations.

Laterality in Speech and Reading Difficulties

Speech defects, especially those without obvious organic cause, mirror writing, and reversals in reading, writing, and spelling, are suggestive of lateral dominance anomalies. However, they are by no means specific symptoms of the conditions. Reversals in reading, for example, occur frequently through the first two or three grades of school and are of little importance in connection with lateral dominance variations unless they remain quite troublesome beyond the third grade.

[18]Cobb, S., *Op. Cit.*, pp. 4–46.
[19]Cornil, L., and H. Gastaut, "Electroencephalographic Study of Sensory Dominance of One Cerebral Hemisphere," *Presse Medicale* (Paris), 55: 421, June 21, 1947.
[20]Lindsley, D. B., *Op.Cit.*
[21]Orton, S. T., *Reading, Writing and Speech Problems in Children*, p. 215. W. W. Norton, New York, 1937.
[22]Dearborn, W. F., "Structural Factors Which Condition Special Disability in Reading," *Proceedings of the American Association for Mental Deficiency*, 38: 266–283, 1933.

Many tests have been devised for detecting departures from dextrality and there are a great many tests available for detection or measurement of laterality. These consist of tests for eye dominance, for hand dominance, batteries including tests for both of these together with foot dominance, and tests of eyedness while reading. They involve such factors as preference, accuracy, speed, and strength. Questionnaires are sometimes used. They are not too satisfactory because many of the pupils to be tested are too young to give reliable answers, while the older students often have forgotten some of the more important dominance facts of their earlier history. In addition to the formal tests there are a number of simple techniques any teacher may use. These include questions or observation of which hand the child uses in writing, drawing, picking things up, throwing, batting, sweeping, and reaching.

Difference in the sharpness of vision (visual acuity) of the two eyes is sometimes thought to determine eye dominance. This is not always so since dominance is a cerebral rather than a peripheral function. However, the idea springs from the fact that if a potentially dominant eye is blind or nearly so and the other has considerably better vision the individual will respond to dominance tests with the better eye. One sees frequent cases of eye dominance in the eye with poorer usable vision and so it is not safe to rely on visual acuity as an indicator of ocular dominance. Although some cling to the idea that left eyedness or left handedness is a cause of language failures, current opinion appears to be that neither is as important as uncertain dominance.

Few people who are in a position to know still consider dominance variations as principal causes of reading and spelling failure, although they feel that such conditions *may* be of importance in some cases. The relationship of left dominance (sinistrality) to the production of mirror script is probably a little closer and perhaps somewhat more important than that of any of the lateral dominance variations to reading and spelling, while the relationship of uncertain dominance to speech difficulties is probably the best understood and the most important. When treated, it is the most likely to result in improvement in that branch of language function.

When a child with speech difficulties is found to present ambidexterity (uncertain dominance) the attempt is often made to transfer all dominance to the preferred side[23] or, if there is a history of change having been brought about in early life by a misguided parent or teacher, the child is forced to use the side which appears to have been dominant in the first place, unless he exhibits signs of nervous or emotional complications. Methods include techniques directed to vision and to general activities. For example, the eye from which dominance is to be diverted may be occluded with an eye patch, translucent lens or colored lens. Bimanual activities, such as typing and the playing of the flute or piano are forbidden, simultaneous talking and writing and other exercises are sometimes used. Various investigators[24,25] are once again advising that some left-handed children may be taught to use the right hand and to write from left to right with it.

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[23]Van Riper, C., *Speech Correction, Principles and Methods*, Ed II. p. 337. Prentice Hall, New York, 1949.

[24]Blau, A., *The Master Hand.* American Orthopsychiatric Association Res.Monograph, 5, New York, 1946.

[25]Eustis, R. S., "Right or Left Handedness." *New England Journal of Medicine*, 240: 249–253, February 17, 1949.

Teachers should not attempt to alter the cerebral dominance of their pupils. Changes of eye dominance should be made only by or under the direction of an eye doctor. Changes of handedness are often attempted by persons trained in medicine, psychology, or speech correction. At any rate changes should be made only by those with special training. Before deciding to attempt a change in lateral dominance the doctor will try to determine whether the child's present dominance habits are physiologic or the result of environmental influences. If they are principally of the latter type an attempted change is more likely to be successful than if they are of the former variety. As a matter of fact, except, perhaps, for cases of speech difficulty, it is probable that interference with cerebral dominance is productive of more emotional and nervous disturbance than the reading, writing, and spelling difficulties which the change is hoped to improve. The techniques involved serve to direct the child's attention to himself as a special problem and to the extent that they do are undesirable.

A few years ago the concept of eye control as different from eye dominance was brought forward.[26] Speech, reading, and writing difficulties were deemed likely to follow when one eye was the dominant eye and the other the controlling eye. The concept is of psychological interest. Its practical value to the teacher has yet to be determined.

Some of the things that would lead a teacher to suspect dominance variations among pupils include reversals or inversions of letters, digits, and words, mirror reading or writing, a history of a previous change in handedness or eyedness, or indiscriminate use of either hand with reasonably successful results. Speech difficulties are sometimes suggestive of lateral dominance variations.

Some techniques that are used to help the child whose dominance conditions are thought to be interfering with his learning include the following. At the kindergarten or elementary grade level simple exercises emphasizing the left to right approach may be employed. Pictures with objects moving from left to right and a pointer moving in the same direction under pictures or print on the board or in books is thought to be helpful. From first grade on words and sentences can be discussed as growing from left to right and the reading films, such as those of the Harvard University Press or the Reading Laboratory of the State University of Iowa, can be fitted into the instructional program. Games can be developed around starting at the left end of words, such as the familiar ones of marking the first letter green for go and the last red for stop, or starting with the initial consonants of words and guessing at the rest. Those using a phonic approach can demonstrate how sounding a word from left to right produces a word sound with meaning, while sounding in the right to left direction produces nonsense. Reversible words and letters receive special attention. Reading material on board or text may be covered with a card, which is moved to the right exposing more words. The use of a tracing finger moving from left to right under each line is legitimate, although it creates a habit that has to be unlearned later. Bimanual typewriting has been sworn by and at by different teachers, some claiming that the bimanual activity helps to offset unfavorable dominance tendencies, while others feel that it favors the development of uncertain dominance.

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[26]Berner, G. E., and D. E. Berner, "Relation of Ocular Dominance, Handedness and the Controlling Eye in Binocular Vision," *Archives of Ophthalmology*, 50: 603–608, November 1953.

Stuttering is sometimes deemed the result of poorly coordinated innervation to the paired musculature of speech, the non-dominant hemisphere of the brain interfering with the integrations of the dominant side. Van Riper favors, among other factors in treatment, the encouragement of unilaterality and the avoidance of bimanual activities. On the other hand other speech correctionists have urged a more or less arbitrary change of handedness. There appears to be no general consensus of opinion and little or no scientific evidence to support either approach. My own observation has been that interference with lateral dominance is not the method of choice in any form of language difficulty.

Transfer. Among the many forms of transfer of training discussed by educational psychologists is bilateral transfer in which training of one of a pair of organs, such as the hand, is reflected in the improved performance of the opposite member. Certain studies on the neurology of transfer have been made in recent years by Sperry.[27, 28, 29] His studies appear to indicate that the surgical severance of the two cerebral hemispheres by an incision passing through the corpus callosum and the optic chiasm will *prevent transfer* from one to the other. After such surgery he has covered one eye of his laboratory animals and taught them certain things. Then covering the eye used in the learning and uncovering the opposite he has presented the appropriate situation to the animal and has found no evidence of transfer. If the learning precedes the surgical section of chiasm and callosum, its effect can be detected in both hemispheres but further learning cannot transfer, presumably because both hemispheres have been separated. After the operation visual learning and memory appear to occur independently in the right and left hemispheres.

Intelligence. Probably intelligence, as measured by the common intelligence tests, can be defined as the ability to achieve in the schools of the country in which the test was standardized. The nature of intelligence is not known. Psychological theories are many and serviceable but do not answer the fundamental question. This author regards intelligence as a functional manifestation of the integrity of the central nervous system. The idea implies that the degree of intelligence manifested by an individual bears a relationship to the structural and functional state of his brain. Damage or failure of development or better than average development of a part of it is likely to produce corresponding variations in the capacity to perform the functions affected by the part.

Various investigators have attempted to localize intelligence but without much success. Some have claimed that the knowledge of facts involves that portion of the brain from Brodmann area 6 to the occipital lobe, while the frontal lobes are generally the seat of emotion and wisdom, the latter being defined as the ability to *use* facts. It has been pointed out that loss of the frontal lobes has little effect on the store of facts but interferes with their application to problems. For what it may be worth here reference is made to a ten-year study of prefrontal lobe surgery in which observation

[27] Sperry, R. W., "Experiments on Perceptual Integration in Animals," *Psychiatric Research Reports*, 6: 151–160, American Psychiatric Association, October 1956.

[28] Sperry, R. W., J. S. Stamm, and N. Miner, "Relearning Tests for Interocular Transfer Following Division of Optic Chiasma and Corpus Callosum in Cats," *Journal of Comparative and Physiological Psychology*, 49: 529–533, December 1956.

[29] Stamm, J. S., and R. W. Sperry, "Function of Corpus Callosum in Contralateral Transfer of Somesthetic Discrimination in Cats," *Journal of Comparative and Physiological Psychology*, 50: 138–143, April 1957.

and psychological testing after operation revealed no intellectual impairment or defects in retention, memory, or concentration.[30]

Gross and histological (microscopic) studies of brains fail to reveal much difference between bright and dull people, although the idiot brain *tends* to be smaller, less well developed, and with more defects than those of others. Comparative anatomy discloses a marked difference among different species. The bird brain tends to be simple and lacking the convolutions seen in the brains of higher animals. The higher in the phylogenic scale the more convolutions appear in the brains of the members of each species, thus increasing the area of the gray matter which, as has been stated earlier, consists largely of the nerve cells themselves. Apparently the area of the cortex and the number of neurons in it bears some direct relation to the degree of intelligence.

Notwithstanding interesting speculations on brain structure as related to intelligence and the implied capacity to learn, the fact remains that in the present state of scientific knowledge the psychologist offers more than the neurologist, since the former has occupied himself with observed behavior and can give us immediate practical assistance with learning problems among people of all ages and degrees of mental capacity. However, recent experience in studying the development of learning in the Rhesus monkey indicates great research potential for studies involving neurological, biochemical, and pharmacological aspects of learning and behavior.[31]

Individual Differences in Intelligence

A distribution of the intelligence test scores of large numbers of people yields a normal curve, with the majority clustered in the middle and the numbers diminishing on either side, as the score levels increase on one side and decrease on the other. Terman[32] reported that 2.63% of 905 unselected children between the ages of five and fourteen presented IQs below 75 while 11.23% fell below 85. If these figures are correct, teachers, especially in the lower grades, may expect some learning trouble in approximately 10% of their pupils unless, as is frequently done in recent years, some screening process is applied to school entrants so as to exclude those whose mental maturity is insufficient to allow them to do the work of the first grade successfully.

Of course, children with IQs close to 100 (normal or average) usually have little trouble in the grades but children with considerably higher IQs, though even better able to do the work, are often bored by its simplicity (to them), and turn to misbehavior to amuse themselves. They are as out of place in a grade corresponding to their chronological age as are those whose IQs are as much lower than the average, because of the difference between their ability and that of the majority of their classmates. Practically, one might think of the child with a high IQ as mentally older, and one with a low IQ as mentally younger than the average. This is somewhat more obvious when mental age scores are used instead of IQs. The child with a high IQ has a higher than average mental age, while the one with a

[30]Slocum, J., C. L. Bennett, and J. L. Pool, "The Role of Prefrontal Lobe Surgery as a Means of Eradicating Intractable Anxiety," *American Journal of Psychiatry*, 116: 222–228, 1959.

[31]Harlow, H. F., "The Development of Learning in the Rhesus Monkey," *American Scientist*, 47: 459–479, December 1959.

[32]Terman, L. M., *The Measurement of Intelligence*, p. 66. Houghton Mifflin Co., Boston, 1916.

low IQ has a mental age that is lower than his chronological age. The IQ, of course, is the ratio of mental age to chronological age, i.e. MA/CA = IQ.

The child with a low IQ (and low mental age) usually receives more attention because he has so much trouble in learning, while the pupil with a high IQ (and high mental age) is often left to get along as best he can since the teacher knows that he can do the work if he wishes.

The Superior Child. Recent developments in international politics have focused attention on the enormous potential of the superior pupil. It is to be devoutly hoped that his capacity for making a larger than average social contribution will continue to be valued and that the day of dragging him down to a dead level of stultifying mediocrity is over. "Superior" describes these children better than "gifted" because they are really so both physically and mentally. Statistically they tend to be heavier and better built, with fewer defects. They are usually socially acceptable and do everything average or slightly below average children do but they do it better and have other interests as well. Their efforts are more systematic and better directed and they appear to prefer school subjects which require more abstract thought.

Superior children read more books and choose more mature ones than others of their age. They are more curious and creative and their success beyond the school years tends to parallel their school achievement. Contrasting a quick random sampling of my own superior cases, now grown up, with a similar group in the 80–95 IQ range revealed occupations among the former of admiral, bishop, research chemist, research physicist, and the like, while the latter group presented occupations of factory hand, clerk in store, radio service man, and waitress.

Teachers of superior children should permit them to set their own pace if it tends to exceed that of their classmates. If such a child reaches an academic stage so disproportionate to his social age that he is unhappy, play contacts at an appropriate age level can be arranged for him. My experience is that they are usually adaptable enough so that this is not necessary, but such a condition is conceivable and should be given attention if it occurs. Permit such children to make and enjoy friendships at their own mental level, even if it means running with an older crowd. Stimulate such a child to use his capacity, enrich his curriculum, provide special projects within his grade or accelerate him if his performance warrants before boredom robs him of his will to achieve. Give him plenty of opportunity to experiment and try his wings, help him to follow up interests and show him how to attain such goals as he may set.

When a pupil's general ability (intelligence) is lower than that of his classmates, learning at their level is very difficult for him. The greater the discrepancy between his ability and theirs the less likely he is to learn.

Dullness and Mental Deficiency. Children who exhibit a marked mental deficiency are said to be feebleminded. For convenience it is usually stated that individuals with IQs of 70 or less fall in this category. School people experience a good deal of difficulty with the borderline cases, with IQs between 70 and 90, and refer to them by the euphemistic term "dull" or, when at the higher end of the range, the misleading term "dull normals." Feeblemindedness occurs in about 2% of the population. About a quarter of the cases are believed to be due to defective germ-plasm or aplasia (defective development or absence of a part of the brain); the other three-quarters to inflammatory causes, or injuries. The etiological problem is

largely of the same nature as that met in connection with other defects of the nervous system.

Among the conditions believed to contribute to mental defectiveness are prenatal influences, prematurity of birth, consanguinity of parents, birth injuries, diffuse sclerosis, microcephaly, hydrocephaly, encephalitis, syphilis, tuberculosis, endocrine disorders, and others. Whooping cough[33] or poliomyelitis[34] may interfere with mental development when contracted at an early age. Groups of children with cerebral palsy who exhibit rigidity tend to display a disproportionate number of mental defectives.[35] The damage is often in the frontal lobes of the brain (Brodmann areas 9 through 12).

The feebleminded child is unable to learn in proportion to his chronological age, he has trouble in grasping new facts and in adapting himself to new situations, and his memory is poor. He may be apathetic or overactive, may be self-assertive, is likely to be inconsiderate of others, tends to be happy and often silly. Many of them exhibit morbid hunger.

Feeblemindedness occurs in variable degrees from mild to severe. It is usually classified by IQ; those with IQs from 0 to 20 being termed idiots, those with IQs from 20 to 50 imbeciles, and those with IQs from 50 to 70 as morons. Morons exhibit few characteristics that mark them from other people. They tend to be childlike at all ages and have trouble in learning. Imbeciles are likely to present congenital defects or paralyses. The brains of some of them are smaller than the average and have more than the usual amount of supporting structure (neuroglia). Idiots rarely enter regular schools because their defectiveness is so marked that parents cannot overlook it and development is so slow that it is obvious to all that the child is not ready for the school experience. Pathological changes in the skull and brain are common in this group and some of the stigmata of degeneracy are usually present. These include deformed ears, cleft palate, harelip, and asymetry of the body.

The outlook for the feebleminded child varies with his degree of defectiveness. The mentality of idiots rarely develops beyond that of the preschool child. Imbeciles may do the work of the first two grades after a fashion and can acquire such simple skills as mat and brush making or very uncomplicated weaving. Some do surprisingly well, especially under sympathetic management and instruction. Morons may be able to support themselves in the community and often do. They are reasonably successful at bench work, printing, painting, shoe repairing, small truck driving, and often make good domestic servants or farm hands.

The "dull" individual who stands between the moron and the average or "normal" may succeed in getting through junior high school if he is a dogged plugger and willing to work. Some go even farther but only to the extent of their social adaptability and capacity for hard work. This is especially true of those with IQs from 70 to 85 and to a lesser extent of those with IQs between 85 and 90. People in the latter range tend to do better than the others, partly because they have more mental capacity and partly because their inferiority is not so obvious to those they meet socially. People in the entire "dull" range experience difficulty in doing

[33]Levy, S., and H. A. Perry, "Pertussis as a Cause of Mental Deficiency," *American Journal of Mental Deficiency*, 52: 217–226, January 1948.

[34]Meyers, E., "Psychological Considerations in a Group of Children with Poliomyelitis," *Journal of Pediatrics*, 31: 34–48, July 1947.

[35]Burgemeister, B. B., and L. H. Blum, "Intellectual Evaluation of a Group of Cerebral Palsied Children," *Nervous Child*, 8: 177–180, April 1949.

abstract thinking and tasks in which it is necessary. They make out better as doers rather than thinkers and work better under some degree of direction or kindly supervision. However, they can learn factual material in the elementary grades if not hurried. As they approach their ability ceiling, progress slows down. In other words the learning curve begins to flatten out into a plateau and the effort necessary on the part of both pupil and teacher becomes increasingly great in proportion to the amount learned until it is obvious to all that the practical limit has been reached. Beyond this the amount learned does not warrant the effort required.

Dull pupils are easily upset emotionally when parents and teachers expect too much of them, such as holding them up to the rate and degree of progress being made by normal schoolmates or relatives, or demanding that they attain educational levels beyond their learning capacity. Frequent failure leads to discouragement for them. They also experience bitter disappointments, many having set their hearts on entering some profession beyond their capacity. These people fit into a simple society and do very well. Many find satisfactory and useful situations in rural and industrial life.

Dull and mentally defective persons should be taught up to the limit of their capacity to learn. In doing so emphasize the basic elementary school skills and if upper grades are reached, try to relate these skills to adult problems. Vocational training is desirable and the pupil should be led to feel that all jobs are honorable and worth while if they make a social contribution. Too often the vocational classes are considered dumping grounds for the unfit when they should be esteemed and used for what they are — places where opportunity is given and where an individual can develop practical skills and prepare for a satisfactory, socially productive life. There is no real difference in the purpose of a class for future mechanics' helpers and another for teachers. Both are preparing the student for socially contributive self-support and hence are vocational.

In addition to the educational aims mentioned in the previous paragraph another consists of introducing the dull or more deficient persons to handwork and sports which may appeal to them in the field of avocation. One of the most important aspects of the treatment of dull people is to help them to get along with others and to fit into the social system in which they live. Since they find abstract thinking difficult and are sometimes quite hazy as to what is "good" or "bad," emphasis should be put on teaching them *habits* of responsibility, honesty, and consideration for others.

Some dull pupils will be able to remain in regular classes for a time while others will do better in special class. Placement should be determined to some extent by mental age and the pupil should not be expected to exceed the tasks appropriate to this level. Some mentally defective children may also remain in regular classes for the early part of their school lives but sooner or later transfer to special class becomes necessary. It is a mistake, however, to transfer older pupils of this type to vocational classes unless their capacity is sufficient for them to profit by vocational training. Pupils found to be very defective should be institutionalized. This can be determined and carried out through the school health authorities. Many children who are unable to make progress in regular school classes may do better and make surprising gains (within the limits of ability and the amount of time available) if transferred to special state or private schools intended for mentally retarded pupils.

The prospect for recovery of a child of limited intelligence is poor. When the cause of the mental defectiveness is disease, such as cretinism or myxedema, appropriate medical treatment may produce some improvement, but in most cases one can only attempt to help the child to make use of such ability as he has. This includes the teaching of desirable habits of behavior to take the place of the attitudes and ideals the individual may always remain too immature to form for himself. Provision should be made for instruction up to the ceiling of the child's ability to learn or at least to the practical instructional limit.

Zimmerman and others have been studying glutamic acid therapy among mentally retarded people and their first report summarizing thirteen years of investigation appeared in May 1959.[36] This medication appears to be related to the formation of acetylcholine, which is a component of the synaptic electrolyte. After six months of treatment the intelligence quotient of the group rose 5.49 points. Performance scores were not raised to a significant degree, but there was an improvement rate of 64% on behavioral traits. Slow, withdrawn, unresponsive, and depressed children made the best responses. Further reports will be awaited with interest. Rudolf treated a group of 90 defectives who had shown no improvement for a year or more, with thiamine and reported an increased IQ in 17 and improved social age in 20.[37]

Beck, McKhann, and Belknap have attempted to increase the blood supply of the brain by surgery[38] but I have seen no recent report of their results.

Emotion in the Classroom

There are various physical aspects of emotion that the teacher can observe in her pupils. These include facial expressions such as smiles, frowns, threatening attitudes, defensive acts, flushing or paleness, and unexplained perspiration. The pupil may complain of nausea, churning of the stomach, or the need to go to the basement. Occasionally when a child is under severe emotional tension he will soil himself.

Teachers can help emotionally inclined students by teaching them good emotional habits. They can help pupils to face reality and not run away from it. They can train the pupils in cooperative effort, the habit of working with others. They should be sure that the tasks set are within the ability of the students to perform them and adjust school demands to the ability level of their classes. They can maintain kindly but clear-cut discipline, give adequate but not gushy recognition for work well done, and should try to make the children feel that they are a part of the school, that they are wanted there and that they belong.

Emotion. Emotions are physical responses to environmental stress of one kind or another. The feelings are probably originated in the cerebral cortex where they are experienced by the individual. There seems a good probability that the hypothalamus sensitizes the thalamus and that these

[36]Zimmerman, F. T., and B. Burgemeister, "A Controlled Experiment of Glutamic Acid Therapy," *Archives of Neurology and Psychiatry*, 81: 639–648, May 1959.

[37]Rudolf, G. deM., "The Treatment of Mental Defectives with Thiamine," *Journal of Medical Science*, 95: 698–702, 1949.

[38]Beck, C. S., McKhann, and W. D. Belknap, "Revascularization of the Brain Through Establishment of a Cervical Arteriovenous Fistula." *Journal of Pediatrics*, 35: 317–329, September 1949.

structures produce the overt expression of the emotion but not the feeling itself. Possibly they influence the intensity of awareness. Electrical stimulation of the hypothalamus results in emotional behavior but appears to do so without any subjective feeling. The autonomic nervous system is an important part of the mechanism of emotion. It acts as a regulator to keep the individual in equilibrium. This latter manages the body in its regular day by day living but at times of stress or crisis the sympathetic inhibits the parasympathetic and prepares the individual for whatever trouble may be in store for him. It increases the heart rate, slows or stops digestion and elimination, increases available energy by raising the blood sugar, and adds to drive by causing the adrenal (suprarenal) glands to discharge more adrenalin (epinephrine) into the blood stream.

Most of the endocrine glands are involved in emotion to some degree but the thyroid and adrenals appear to be most intimately related to it. Both influence the pupil's drive and willingness to work at his assignments. The level of nervousness, anxiety, and euphoria is strongly influenced by the degree of activity of the thyroid, while the adrenals affect temperamental changes, associated with defense or offense. The endocrine glands are under the control of the hypothalamus which also tends to integrate feeling into the overt expressions of emotion. Apparently the emotional feelings arise in the cortex and influence the hypothalamus, which sets off, not only characteristic behavior which can be observed, but also many internal preparations for meeting stress, of which the endocrine responses are a part.

Although emotion is a manifestation of a very widespread cerebral process, the frontal lobes appear to be somewhat more involved than other parts of the brain. This is emphasized by the familiar story of the man who was tamping a dynamite charge which went off and drove the bar through his frontal lobes. He recovered but exhibited marked emotional and personality changes. His skull has been on display for many years in the Warren Anatomical Museum at Harvard Medical School. More recent experiences with frontal lobe surgery have shown that it is possible to bring about more or less selective changes in the emotional state. Inadaptability, hostility, and destructiveness have been reduced through such surgical procedures. Freedom from worry has been a fairly frequent achievement. Evidence accumulating from studies and surgical experience indicates that the frontal lobes have something to do with learning, memory, personality, initiative, tactfulness, and emotion. Disorders in the general region of Brodmann areas 9 thru 12 have been claimed to interfere with memory and the grasping of new facts. It has been asserted that sometimes intelligence is retarded.

CHAPTER 2

Some Glandular Bases of Learning

Learning and the Endocrine Glands. The ability to learn is strongly influenced by the endocrine glands. The relationship between learning and endocrine factors has not been as thoroughly explored as it should be because it usually requires medical laboratory work and this puts research in this particular field beyond the reach of most educators. A few studies, such as that of Dr. Helen Robinson,[1] have been carried on through the cooperation of educators and endocrinologists but it is hard to attain sufficient team work because of the unfamiliarity of each group with the point of view, interests, aims, and ideals of the other.

Mental retardation is a widely recognized cause of school failure and it is well known that it sometimes results from certain endocrine difficulties. Reports calling attention to this include those of Wagner,[2] J. F. Robinson,[3] and McCullagh.[4] A number of endocrine disorders produce a low basal metabolic rate (B.M.R.) in persons affected and McCurdy[5] has reported a relationship between the B.M.R. and academic performance. Another well recognized cause of retardation in school is eye trouble. It is fairly obvious that a child who has a visual defect or who finds seeing a tiring, difficult act is likely to be handicapped in book, desk, and board work. Endocrinologists and ophthalmologists know that certain endocrine disorders interfere with eye function. Abraham[6] pointed out an important relationship between the B.M.R. and the convergence function; the aiming of the eyes in binocular vision. Deficiency of convergence may lead to regressions, omissions, loss of place, rapid fatigue, and other errors in reading. Tassman[7] lists difficult focusing (ciliary spasm), deviating eyes (strabismus), juvenile cataract, retinal lesions and field defects (bitemporal hemianopsia) occurring, at least to some extent, as results of various endocrine malfunctions. Durrell,[8] Gates,[9] Monroe and Bachus,[10] Olson,[11] and Witty and Kopel,[12]

[1]Robinson, H. M., *Why Pupils Fail in Reading.* University of Chicago Press, Chicago, 1946.
[2]Wagner, R., "Endocrine and Pseudoendocrine Problems in Childhood." *New England Journal of Medicine*, 229: 737, 1943.
[3]Robinson, J. F., "Recent Developments in Physical, Physiological and Pharmacological Procedures in the Treatment of the Exceptional Child." *Some Contemporary Thinking about the Exceptional Child*, 11: 34–45, The Woods School, Langhorne, Pa., 1949.
[4]McCullagh, E. P., "The Value and Limitations of Endocrine Therapy in the Exceptional Child. Review of Psychiatric Progress as Related to Exceptional Children." *Proceedings of the Eleventh Institute of the Child Research Clinic of the Woods School in Collaboration with Western Reserve University*, 49–55, Langhorne, Pa. 1944.
[5]McCurdy, H. G., "Basal metabolism and Academic Performance in a sample of College Women." *Journal of Educational Psychology*, 38: 363–372, Oct. 1937.
[6]Abraham, S. V., "The Convergence Function in Relation to the Basal Metabolism." *American Journal of Ophthalmology*, 26: 400–403, April 1943.
[7]Tassman, I. S., *Eye Manifestations of Internal Diseases.* C. V. Mosby Co., St. Louis, 1951.
[8]Durrell, D. D., *Improvement of Basic Reading Abilities.* World Book Co., Yonkers, N. Y., 1940.
[9]Gates, A. I., *Diagnosis and Treatment of Extreme Cases of Reading Disability.* 36th Yearbook of the National Society for the Study of Education. Part I. The Teaching of Reading: A Second Report, p. 398. Public School Publishing Co., Bloomington, Ill., 1937.
[10]Monroe, M., and B. Bachus, *Remedial Reading*, p. 21. Monograph in Character Education. Houghton Mifflin Co., Boston, 1937.
[11]Olson, W. C., "Reading as a Function of the Total Growth of the Child." *Reading and Pupil Development*, W. S. Gray, Ed., Supplementary Monographs, 51: 233–237, University of Chicago, Chicago, 1940.
[12]Witty, P., and D. Kopel, *Reading and the Educative Process*, pp. 216–218. Ginn & Co., Boston, 1939.

all call attention to the probable handicapping effect that endocrine difficulties may have on reading ability, while Harris[13] reports that children with endocrine disturbances have been found more frequently among reading difficulty cases than in a normal child population. The author's findings[14, 15] corroborate this. I have found a higher incidence of endocrine disease among reading failures. Some years ago Mateer[16] reported a high incidence of reading failure among cases of pituitary dysfunction.

The Endocrine Glands

Brain			Hypothalamus			
Endocrine Gland System			Pituitary			
Thyroid	Parathyroids (4)	Adrenals (2)	Gonads (2)	Pancreas (part)	Thymus	
		Hormones				
Body		Organs				

There is some variation in the organs usually classified as endocrine glands. The ones presented here are included in most classifications and are the principal glands of the endocrine system.

The Endocrine System. The endocrine glands are structures which form chemical substances, called hormones, and empty them into the blood stream. They regulate the transmission of nervous stimulation, metabolism, blood pressure, blood calcium, salt and water balance, digestion, growth, reproduction, and other functions. Through some of these activities they have a strong influence on the school child's intelligence, attention, concentration, drive, and emotions. The glands have an elaborate interdependent relationship, and when their balance is disturbed, perhaps by the over- or under-activity of one of the glands, the whole system may be affected.

The glands themselves are controlled by the hypothalamus, which in turn controls the pituitary gland. This gland is the coordinator of all of the others, including the thyroid, parathyroids, suprarenals (adrenals), ovaries, testes, the islands of Langerhans in the pancreas, and the thymus. The endocrine system might be likened to a college faculty: the hypothalamus is the president, the pituitary is the dean, while the rest of the glands are professors. One might go even farther and liken the hormones of these glands to the instructors and the organs they affect to the students.

My observations of *endocrine disorders* among school failures and non-failures indicate that they occur in about 2% of the general school population and in about 3% of failures. Robinson[17] found a considerably higher incidence in her study of reading difficulty. My endocrine cases, as a group, presented tendencies for sight vocabulary to be lower and emotional reactions to school failure greater than among cases without endocrine disturbances. A study of my reading failure cases showed that the commonest

[13]Harris, A. J., *How to Increase Reading Ability*, p. 219. Longmans, Green & Co., New York, 1948.

[14]Eames, T. H., "The Effect of Endocrine Disorders on Reading." *The Reading Teacher* 12: 263, 266, April 1959.

[15]Eames, T. H., "The Incidence of Diseases Among Reading Failures and Non-failures." *Journal of Pediatrics* 33: 614–617, November 1948.

[16]Mateer, F. A., A First Study of Pituitary Dysfunction. *Psychological Bulletin* 32: 736, 1935.

[17]Robinson, H. M., *Op.Cit.*

endocrine condition among them was hypothyroidism (insufficient thyroid hormone); next the hypopituitary group (insufficient pituitary hormones), then the hyperthyroid cases (excess of thyroid hormone) and a scattering of other types at the end. The educational implications of endocrine function and dysfunction will be discussed gland by gland in view of the diversity of action and effect of the different members of the endocrine system. First the basal metabolic rate will be considered since many of the research reports in the literature use this measure in bringing out relationships to intelligence and other conditions of interest to teachers.

Basal Metabolic Rate and Learning. Basal metabolism may be thought of as the minimum amount of energy necessary to maintain cellular activity in the body when the individual is completely at rest. The measurement of the B.M.R. is expressed numerically. The figure varies on either side of the norm according to the presence and degree of certain different diseases. When it is higher than normal the child is likely to be nervous, jumpy, sometimes emotionally unstable, is fired with energy and seems to have a special capacity for getting into mischief in and out of the classroom. When the B.M.R. is low, on the other hand, the child's effort is poor, he lacks initiative and drive, seems lazy and unwilling to try to complete his assignments. He may not work up to his mental age level, since in mild to medium cases such a child may be stimulated by the psychometric test situation and work a little harder than usual during the test, but cannot sustain that level of performance in day-to-day school work. Sometimes, in medium to high degrees of the condition the child earns a psychometric rating lower than his potentialities.

The child with pituitary deficiencies may have a low B.M.R. and exhibit school behavior characteristic of it. The same condition occurs in combined deficiencies of the pituitary and thyroid glands but is most frequently seen in groups of pupils with hypothyroidism. Abraham has reported a relationship between basal metabolism and the convergence function, or the aiming of the eyes at fixation points, such as is done in reading and school work.[18]

The Pituitary Gland. This gland regulates the entire endocrine system. A variety of hormones are produced and evidences of excess or deficiency depend on which hormone is affected. The gland is a small, round, grayish-red organ, attached to the brain by a stalk and lying in a depression in the sphenoid bone near the hypothalamus. In other words it is in the head, closely attached to the brain. It has three lobes. When the anterior lobe is affected any of several general reactions are likely to occur. Deficiency of the growth hormone makes the child symmetrically dwarfed. He is a tiny but well-formed person. When the gonadotrophic hormone is deficient the child remains small and immature and he retains his appearance of immaturity into adulthood. Such children are often overweight and exhibit personality changes. Digestive difficulties are not infrequent and they interfere further with the child's ability to work at top efficiency. Anterior pituitary deficiency is often accompanied by *mental retardation* and inability to compete with pupils of normal intelligence. Talbot[19] and others studied a group of "thin dwarfs" of the pituitary type and found

[18]Abraham, S. V., *Op. Cit.*

[19]Talbot, N. B., et al. "Dwarfism in Healthy Children." *New England Journal of Medicine*, 236: 783–793, May 22, 1947.

nineteen percent of them to be mentally deficient. The average intelligence quotient was reported to be "about seventy." In some cases these investigators were able to bring about a resumption of normal growth by changes in diet.

Pupils, especially in the upper grades and college, sometimes experience overactivity of the anterior part of the pituitary gland and it produces an excessive amount of the growth hormone. The skeletal *growth becomes more rapid than normal* and continues until the epiphyses (ends) of the bones unite with the shafts. If the disease continues, further changes in the bones occur and the adult is said to have acromegaly. Early in the disease boys tend to exhibit increased libido but pass later into sexual immaturity when the illness has progressed enough to interfere with the production of the gonad factor.

As the disease develops, tumor formation may result in headache, visual field defects *which can interfere with eye span and make more fixations per line necessary in reading*, bitemporal hemianopsia (blindness of the temporal or outer half of the visual field in each eye), and general visual defects, the latter occurring rather late in the disease. Pupils whose only obvious manifestation of the illness is bodily overgrowth may exhibit emotional reactions arising out of their difference from other pupils of the same age. Overgrown students are teased, and their teachers tend to expect as much of them as they would of older children, judging them by their size rather than by their mental or even chronological age. Do not force the overgrown pupil or assign him heavy chores. Remember that he may be big because he is not well.

When the posterior lobe of the pituitary gland is not functioning at a normal rate and its hormones are deficient a disease called diabetes insipidus occurs. This is *not* the same as the common diabetes (diabetes mellitus) which is more familiar to school people. The child with diabetes insipidus (one could call it pituitary diabetes) bothers the teacher with his *frequent requests to go to the bubbler or to the basement.* Although this seems to the teacher to be a behavior problem or evasive maneuver, the pupil really needs both since the disease produces dehydration, increased thirst, and the passage of large quantities of urine. Teachers who have one of these persistent two-finger wavers in their classes should accede to the demand or, in the lower grades at least, expect a puddle.

Sometimes the hormones of both the anterior and posterior lobes of the gland are affected and there is a deficiency of the hormones they produce. This results in what is known as Frohlich's Syndrome.[20] It occurs more commonly in boys, who take on a feminine shape with female distribution of fat and hair, and may exhibit either no mental change or some degree of retardation. They tend to be *inactive and sleepy, are not aggressive, make a poor showing in their studies*, seem to be *unable to attack the work* and exhibit some emotional disturbance which is, at least partly, the result of their changed appearance and the unkind jibes of their classmates. Visual defects, including blind areas and other changes in the visual fields, occur.[21] This may *interfere with the ability to use texts* and to perform other tasks requiring good vision. There may also be *impairment in the eye span* with consequent *increase in the number of fixations required per line of material read.* Some may be *unable to use texts* at all, especially in advanced cases.

[20]McCullagh, E. P., *Op. Cit.*
[21]Tassman, I. S., *Op.Cit.*

The disease may, and often does, progress up to a certain point and then stop.

The Thyroid Gland. The thyroid gland regulates body metabolism and its degree of activity is often expressed in terms of the basal metabolic rate. When this approximates the norm the individual lives at a pace similar to that of the majority but when the rate is higher or lower than the average he can be thought of as *living* at a corresponding rate. Intelligence is greatly influenced by the degree of activity of this gland. When activity falls off, metabolism slows down, the metabolism of the brain cells is reduced, and intellectual capacity diminishes. When the gland is overactive the pupil appears highly stimulated and may achieve more than he did formerly. The highly stimulated child is nervous, active, and often more emotionally tense than before, while the one whose metabolism is diminishing experiences a dulling of emotional response, loses interest, makes less effort in school, and is generally inattentive.

Thyroid gland deficiencies are probably the commonest endocrine disorders that influence school achievement. Their effect varies from mild to severe and usually yields promptly to adequate medical treatment with corresponding improvement in school accomplishment. The thyroid gland is located in the neck in front of the trachea (windpipe). It consists of two lobes connected by an isthmus. Its hormone regulates metabolism.

Both educational and medical authorities recognize the relationship of thyroid disease to intelligence and the ability to do good work in school. Hardly any course in psychology, either general or educational, passes without reference to and sometimes discussion of cretinism and myxedema, which are manifestations of rather marked thyroid deficiency. One of the chief differences between these conditions is that cretinism exists from birth, while myxedema comes on later. The cretin tends to be dwarfed, placid, and mentally deficient. He is usually good-natured, has a hoarse, rough voice, his tongue is oversize and although he may learn to speak, his speech is likely to be somewhat defective. The cretin lacks energy and is not strong. He is likely to feel cold more than others of his age.

If medical treatment is started early in infancy physical development may be relatively normal but the poor mental condition is less affected by treatment and usually persists. Mental development may progress enough for some to enter the lower grades but they soon reach their ability ceiling and go into schools and institutions for the feeble-minded. While this is not a happy picture it is far better than what one sees if medical treatment is not given, in which case there is no improvement of any kind.

On the other hand, the child with myxedema is free of the disease at birth but begins to show signs of thyroid deficiency, usually after the second year. These children develop symptoms and signs similar to those of cretinism. Their hair is dry and often coarse and thin, they are overweight, and perspire very little. *Growth slows down or stops.* The skin, like the hair, becomes dry and lips and tongue grow thick. *Mental retardation*[22] sets in as a result of the lowered metabolism of the brain cells. The eye muscles may swell and this *interferes with the ability to fixate efficiently on text* or other objects, upsets the eye movements and in a few cases produces double vision. The child seems to lose interest at school, he appears lazy and disinterested, his achievement and grades fall off, and finally the teacher realizes that his ability has deteriorated too.

[22]Tassman, I. S., *Op.Cit.*, p. 494.

Medical treatment often causes growth to be resumed and mental ability, achievement, alertness, attention, and attitude to improve. Since the illness is in the nature of a deficiency most cases have to remain under constant or periodic medical supervision and the medication may have to be continued indefinitely but only under the direct orders of a physician. If medical treatment is not provided the disease runs a steady downhill course marked by deterioration of the individual.

Cretinism and myxedema are not the only types of thyroid deficiency. A mild type occurs among young pupils and older students. It is often overlooked because parents, teachers, and sometimes doctors, are fooled by the apparent *disinclination to work, the lack of interest, the dislike for school, poor achievement in studies, and poor attention.* Teachers sometimes say such children are "woolgathering." When you have a "woolgatherer" in your class it is time to wonder how he got that way. Ask yourself if his achievement is below what would be expected in relation to mental age, whether his achievement and grades are poorer than they were six months or a year ago, whether he perspires less than others in the same activities, and whether he has slowed up a little on the playground. Look at him. Are his skin and hair dry? Is he putting on weight? If the answer to most of these questions is "yes," it is time to request that he receive a physical examination.

The diagnosis of thyroid deficiency is a complex matter and an ordinary health screening is unlikely to detect the disease. Since the child appears to be lazy rather than ill, one must guard against the natural tendency to let this obscure the underlying condition. All cases of thyroid deficiency affect learning to some extent. The cretins and myxedema cases, with their fairly obvious defectiveness are not wronged as often as the subclinical hypothyroid children. The latter group present some of the characteristics of the others but to a lesser degree. Very often their school achievement is poor but they run and play in an apparently normal way out of school. Some intense interest, such as television, sports, or model railroading, may stimulate the child and make him appear more alert when out of school and thereby obscure the real cause of his slowness.

Among my cases of less severe hypothyroidism[23] the median basal metabolic rate was minus 25. Temperature, pulse, and respiration were all lower than among non-endocrine cases. The *speed of visual perception was also retarded* and the commonest complaint from teachers was that the children *could not complete their assignments.* Improvement in school work followed medical treatment in 82%, while 66% showed marked improvement, and 16% only a moderate change for the better.

Teaching the thyroid deficient child. The thyroid deficient child should be placed according to his ability level. This is particularly important among cretins and untreated cases of myxedema. Do not push the thyroid deficient child — let him strike his own stride and allow him plenty of time for rest. These suggestions apply to the child who is not under treatment, who is just starting it, or in whom treatment is not very successful. In most cases of milder hypothyroidism the child under treatment becomes able to compete better after a period of from one to three weeks and special consideration in school may be required no longer.

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[23]Eames, T. H., "Eye Conditions in Hypothyroidism." *American Journal of Optometry* and *Archives of the American Academy of Optometry* 35: 425–427, August 1958.

Teaching the child with an overactive thyroid. The pupil with an excess of thyroid activity is seldom an educational problem. His B.M.R. is high and his rate of living is accelerated. The condition is more common in girls between the ages of 8 and 15. They are nervous, excitable, and sometimes emotionally unstable. Weight loss is common. The teacher may notice these things but since achievement in school subjects is usually good she does little or nothing about it. In fact she is not likely to regard the child as ill or handicapped except by personality factors. Many such cases require the doctor's care. The child may have to leave school and live in a non-stimulating environment until appropriate treatment has been carried out.

Another thyroid disease, sometimes seen in schools and capable of interfering with the pupil's achievement, is simple goitre, an overgrowth (hyperplasia) of the thyroid gland. This is more common along the St. Lawrence River and the area of the Great Lakes. It occurs more often in girls and appears in the upper grades. In the localities where it is frequent, there is said to be a correspondingly increased incidence of deaf-mutism, cretinism, and idiocy. The cause is deficiency of iodine in the diet. Since the sea is the common source of iodine, persons far removed from it and from fresh seafood are somewhat more susceptible. In some areas where the disease is common, iodine is given to the pupils at school under medical supervision. The use of iodized table salt is considered beneficial in iodine deficient areas.

The effect of goitre on education is twofold. First the advance of the disease may result in *impaired convergence and fixation* thereby interfering with efficient use of the eyes in learning tasks. In addition to the train of *difficulties in the use of texts* inherent in convergence and fixation difficulties, *fatigue* is a considerable factor. In the second place the rather large, unsightly swelling in the neck attracts the attention of others, calls forth commiserative or derisive comment, makes the pupil self-conscious, and results in *emotional difficulties.*

Parathyroid Glands. These four glands are located behind the lateral lobes of the thyroid. They regulate calcium balance but appear to have no very close connection with learning. Although severe deficiency leads to tetany, milder degrees tend to cause optic nerve and lens changes in the eyes.[24] They predispose to spasm of accommodation, sore eyes, and rapid *fatigue in book and desk work.* Students may find it hard to hold fixation on their books or papers for long periods. Cases are seen more commonly in the upper grades and colleges.

Adrenal Glands. The adrenal (suprarenal) glands exert some influence on learning. It is not fully understood but they are of importance to education in their effect on the pupil's *drive and his fatigability.* There are two glands; one situated on the upper pole of each kidney. They are divided into a central or medullary part and an outer or cortical part. The central part forms the hormone, adrenalin (epinephrine). When the individual is under stress this hormone reenforces sympathetic nervous action and is said to be a sustaining agent for it. If the hormone is deficient in quantity or quality, the ability to withstand stress is impaired. The cortical part of the gland forms the hormone, cortin, which affects growth and development. When this hormone is deficient all the muscles—visceral,

[24]Tassman, I. S., *Op.Cit.*, p. 62.

skeletal, and cardiac—tire quickly. It seems probable that moderate, perhaps subclinical, degrees of deficiency may explain the problem of some of those pupils who are constantly tired or who tire rapidly.

Sometimes there is overgrowth of the outer part of the gland and this may result in bodily changes in both boys and girls. Emotional and psychological difficulties may result. At first, growth may become rapid but it does not continue so, since there is premature union of the epiphyses (ends) of the bones with the shafts. Pupils so affected tend to take on the characteristics of the opposite sex. The *psychological effect* on the adolescent pupil is often a considerable handicap. Comparatively recent developments in the medical treatment of this condition make it possible to overcome it to a very considerable extent.

The Pancreas. The pancreas is both an exocrine and an endocrine gland. It secretes a group of digestive solutions as well as forming the hormone, insulin. This gland is situated in the abdomen. Its exocrine function is of less importance in learning than its endocrine activity. The former has to do with ordinary processes of digestion and, when deficient, may interfere with pupil performance to the extent that any digestive upset would be expected to do. No studies so far have shown any striking relationship between the two. On the other hand the hormone, insulin, is a major factor in carbohydrate metabolism. When deficient, the child develops the disease known as diabetes (diabetes mellitus).

Until the discovery of insulin and its application to the treatment of diabetes, a child with this disease ran a downhill course and came to an early end. When a child receives adequate medical treatment for diabetes (which usually means that he is getting a carefully adjusted dosage of insulin), there is no reason why he should not do as well and live as long as others. However, there are a good many pupils who may not be able to follow the regular program. This is not the usual condition, however.

Visual defects are common and varied. About fourteen percent of diabetics under the age of twenty-one develop cataract. This is an opacity of the lens of the eye and acts like a dirty window, preventing the child from seeing clearly. The condition comes on over a period of weeks, months, or years with gradually failing vision. The cataract may be removed surgically and good vision is often restored in this way. The diabetes also produces changes in the retina which result in poor vision. When such changes are present removal of a cataract does not improve the retinal condition. Diabetes also causes changes in the refraction of the eyes, in their ability to accommodate for different distances and in their coordination. The refractive condition may change with variations in the blood sugar level. If this is at all marked, glasses will not afford maximum help, except when the eye condition coincides with that present when they were prescribed. The general trend is for the eyes to become near-sighted as blood sugar increases, and far-sighted as it decreases.[25]

The accommodation of the eyes in book and desk work tends to become weaker in diabetes and is said to be insufficient. As a result the eyes tire quickly. Some children exhibiting accommodative variations may develop pseudo-myopia. Occasionally eye muscle paralyses occur, which interfere with efficient convergence, fixation, and eye movements in general. They may result in *confusions, omissions, regressions and loss of place in reading.* Changes in the eyes of diabetic children are somewhat less common than

[25]Tassman, I. S., *Op.Cit.*, p. 503.

among diabetic adults, probably because the child has had the disease a shorter time and there has been less time for morbid changes to result from the illness.

Two very upsetting diabetic conditions which can disrupt a classroom are diabetic coma and insulin shock. Diabetic coma is a loss of consciousness resulting from the disease. Although the symptoms and signs vary somewhat, the general picture seen in the classroom is that of an indisposed child who may complain of indigestion, his face may be flushed and his lips cherry red. The mouth is dry and perspiration is scanty. The breath has a sweetish odor, which some consider rather more vinegary than sweet. Gradually the child becomes lethargic, mentally dull, and finally loses consciousness. Should this happen in the classroom the teacher should keep the child warm and call the school physician or nurse, then report to the parents. Ordinarily the principal will know the procedure to follow in any particular school. Parents of diabetic children should inform teachers if they know that the child has the disease.

Insulin shock is somewhat similar to diabetic coma. Whereas the latter is due to diabetes, the former is the result of an excess of insulin. Insulin acts by promoting carbohydrate metabolism. The doctor prescribes enough of it to make up the deficiency produced by the diabetes. Dietary and other variations may upset the delicate balance with the result that there is not enough carbohydrate in the child to utilize the insulin dose. Insulin shock comes on with pallor, lassitude, weakness, dizziness, and sweating. The small child is fretful and emotional while the older pupil may complain of digestive disturbance and double vision. Sometimes muscular trembling may be observed. Severe cases may pass into semi-consciousness and exhibit paralysis and incontinence, while in very severe cases the individual may lose consciousness completely. Cecil[26] states that the symptoms of overdose of insulin may come on in from one to twenty minutes. Holt,[27] a noted pediatrician, advised that the diabetic child carry a lump of candy or sugar to take when the symptoms of insulin shock appear. This is to provide more carbohydrate to use up the excess of insulin. Orange juice is sometimes used for the same purpose. The teacher should not take responsibility for giving this unless specifically directed by parents or physician. Even then it is best to get written and signed instructions from the parents.

When a child shows signs of insulin shock the teacher proceeds as she does in diabetic coma; notifies the school medical authorities through the proper channels and then reports it to the parents.

Many diabetic children have poor resistance to colds and do not heal readily when cut or scratched. For this reason a classroom with sneezing, coughing children is not the best place for a diabetic child. Sometimes their activities on the playground have to be curtailed because of the danger of injury.

Thymus Gland. The thymus gland probably has little or no effect on school performance at any school age.

Sex glands. The sex glands are not known to have much direct effect on pupil achievement although they have some influence on drive and emotion.

[26]Cecil, R. I., *A Text-Book of Medicine.* W. B. Saunders Co., Philadelphia, 1931.

[27]Holt, L. E., et al., *Holt's Diseases of Infancy and Childhood.* D. Appleton-Century Co., New York, 1933.

Robinson[28] found about seven percent of her poor readers had undescended testes (boys), while Olson[29] thought that delayed descent of the testes might interfere with reading. The sex glands are under the control of the gonadotrophic hormone of the pituitary gland, which causes the development of sexual characteristics at puberty in both girls and boys. *Adolescence* is the period between puberty and maturity. It is a stage of maturation, initiated by the sex glands, which commence to develop adult activities. Children who have been growing at a more or less uniform rate suddenly slow down and shortly pass into a period of greatly accelerated growth, which gradually diminishes and ends at entrance into adulthood. Girls become adolescent earlier than boys and develop more mature interests while the boys are still playing at being space cadets.

The onset of adolescence usually occurs somewhere between 12 and 14 among girls and between 14 and 16 among boys. The delicate balance of the endocrine system is temporarily upset and the child is beset with new sensations, wishes, fears, and doubts which he does not understand. Skin blemishes appear at a time when each sex wishes to look its best. The children begin to take on adult form, with enlargement of pelvis and breasts among the girls and the appearance of beard and lower voice among the boys. Both become reproductively competent.

Educational difficulties at this period stem largely from preoccupation with the social relationships met in secondary school; boy-girl relationships, ranging from multiple dating and running in a mixed crowd to marriage; resentment of authoritarian figures in home and school; and from inherent mating desires and the urge to establish a home and family of their own. Drop-outs result from several of these factors. So do some of the failures where the new life is so preoccupying that studies are forgotten or neglected.

Menstruation. An endocrine function that interferes with achievement in some cases is menstruation. It is a completely normal function resulting from cyclic activity in the pituitary which causes the gonadotrophic hormone to increase and accumulate for successive periods of about 28 days, during which time the lining of the uterus (endometrium) is prepared and held ready for pregnancy. If one has not occurred by the end of the interval the gonadotrophic hormone starts to diminish. With its influence withdrawn the endometrium disintegrates and its fragments mixed with blood from many tiny ruptured blood vessels is cast off. When the process goes on normally the girl has little difficulty with it. Others have painful menses, due to various malfunctions or defects of the parts involved (dysmenorrhea). Girls who experience this may lose as much as a week each month through absence. Those who come to school with considerable discomfort short of prostration are distracted and cannot profit fully from the instruction. Such girls should seek competent medical advice since many of the disturbing causes can be corrected.

[28]Robinson, H. M., *Op.Cit.*, p. 150.
[29]Olson, W. C., *Op.Cit.*

CHAPTER 3

Recent Studies with Learning Implications

There is a definite relationship between the fields of neurology and endocrinology which has considerable bearing on the ability to learn. The nervous system controls the endocrine glands through the hypothalamus which acts on the pituitary gland and the latter controls the endocrine system. Studies are appearing which point up the relationship. Recently Cadilhac, Ribstein, and Jean at the Clinique Saint-Charles reported an electroencephalographic study of metabolic disorders in which they demonstrated E.E.G. changes in a number of syndromes including disturbed carbohydrate metabolism. The differences appeared to be influenced by cerebral maturity and by disturbances of cellular metabolism.[1] It should be recalled that carbohydrate metabolism is greatly influenced by the action of the thyroid gland. Studies of the chemical therapy of mentally retarded children by Kugelmass, of the Department of Health and Hospitals in New York, revealed that thyroid treatment increased the intelligence quotients of young hypothyroid children and that the higher mental levels could be sustained by use of maintenance dosages.[2] This supports earlier observations of the relation of thyroid activity to the ability to learn.

It was also noted that glutamic acid treatment, mentioned in discussion of the work of Zimmerman on an earlier page, was effective in children with mild to moderate defectiveness who exhibited no bizarre behavior. Thiamine, one of the components of the synaptic electrolyte, was found to produce scholastic improvement in malnourished children. Kugelmass also used the drug, phenaglycodol, in mentally deficient cases and found statistically significant improvement in a number of fundamental areas of behavior, most of which involved learning. He felt that, although the drug did not correct the deficiency it helped the children to work up to their available capacities in both individual and group training. However, the favorable changes disappeared when the medication was withdrawn.

Recent contributions to the understanding of memory have come from the experiments of Penfield at the Montreal Neurological Institute of McGill University.[3] These studies involved electrical stimulation of the cortex, resulting in reactivation of recorded consciousness at any random point, with the experience then moving forward. Meyer studied cognitive changes following temporal lobectomy at Maudsley Hospital in London, finding impairment of specific abilities without disturbance of general intelligence when the operation was on the dominant side of the brain, while the same operation on the non-dominant side did not interfere with either intelligence or learning ability.[4] Learning through auditory channels was impaired in operations on the dominant side but no changes were noted in visual or tactile learning ability.

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[1]Cadilhac, J., M. Ribstein, and R. Jean, "E.E.G. et Troubles Metaboliques." *Revue Neurologique*, 100: 270–296, April 1959.

[2]Kugelmass, I. N., "Chemical Therapy of Mentally Retarded Children." *International Record of Medicine*, 172: 119–136, March 1959.

[3]Penfield, W., "The Interpretive Cortex." *Science*, 129: 1719–1725, June 26, 1959.

[4]Meyer, V., "Cognitive Changes Following Temporal Lobectomy for Relief of Temporal Lobe Epilepsy." *Archives of Neurology and Psychiatry*, 81: 299–309, March 1959.

Obviously there is still much to be discovered about the physiology of learning but data is gradually accumulating. One gets impatient waiting for it to appear but extremely interesting and illuminating *new relationships* come into focus as each bit falls into place in the grand picture puzzle that is the human learning and remembering mechanism.

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